Algal Population Dynamics in an Outdoor Algal Raceway

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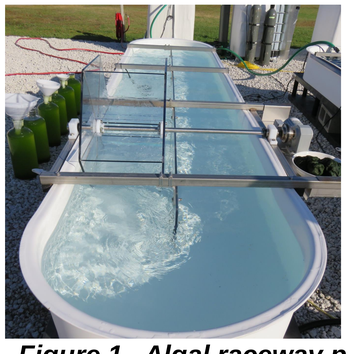
Abstract

With mounting concerns of climate change, society's reliance on fossil fuels must shift toward renewable and sustainable energy-producing systems. Innovative research on the cultivation, growth, harvesting and bioenergy potential of algae may reveal the solution to energy demands of the future. To investigate the scale-up potential of algal systems, outdoor raceway ponds were established and maintained in open conditions to promote interaction with the environment. Open systems, however, are susceptible to seasonal changes such as temperature and as well as changing atmospheric conditions and airborne exposures. A 1000-L open raceway pond was initially inoculated with a local algal mixed culture and population transitions were observed over a one-year experimental period. The pH and temperature were continuously monitored, and pH was controlled by the addition of carbon dioxide on an as-needed basis. The algal cultures were tracked by brightfield microscopy and complex patterns of succession were demonstrated. Within six weeks of inoculation, long filaments fragmented into shorter filaments, followed by complete disappearance of the filamentous algae and displacement by microalgae cultures. The current prevalence of microalgae genera, namely *Scenedesmus* and *Pediastrum*, have been relatively stable for the last six months indicating their persistence despite changing environmental conditions.

Introduction

Open raceway ponds are an ideal place to grow algae in natural sunlight. However, changing environmental conditions affect the ecological succession of algal species. Ecological succession is the gradual process by which ecosystems change over time. Certain parameters such as temperature, photoperiod, and rainfall change according to season and can contribute to the succession of different algal strains.

The structure and rigidity of the cell walls are vastly different between microalgae and filamentous algae and these morphological differences play a significant role in using algal biomass as a feedstock for anaerobic digestion [1].



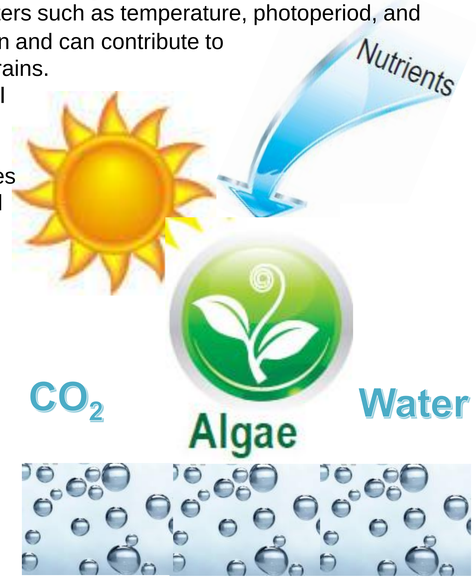


Figure 1. Algal raceway pond before inoculation (left) and factors that contribute to algal growth (right)

Objective

To observe and monitor the succession of algal species in an outdoor raceway pond influenced by naturally occurring environmental changes such as temperature, rainfall, sunlight intensity and light exposure.

Methods

Sample Collection:
- Samples were collected multiple times a week
- Extended over a one-year period

Micrographs:
- Generated using brightfield microscopy
- Algal strains identified according to Standard Methods [2]
- 250x and 400x magnification

Environmental Monitoring:
- pH, temperature, and rainfall

Figure 2. Pond Sampling

Results

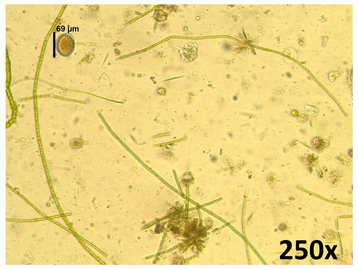


Figure 3. April 2016 (Spring)

Date: April 4, 2016
pH: 7.2
Temperature: 13.3°C
Comments: Initial sample with the presence of both filamentous and microalgae

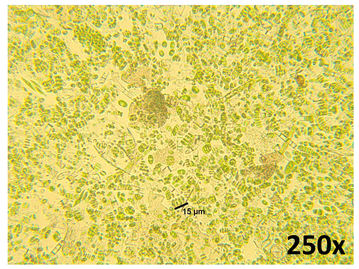


Figure 4. May 2016 (Spring)

Date: May 2, 2016
pH: 7.6
Temperature: 21.6°C
Comments: Filamentous algae have started to fragment and concentration of microalgae has increased

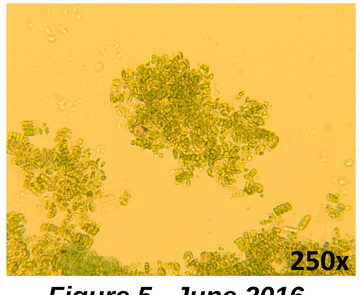


Figure 5. June 2016 (Summer)

Date: June 17, 2016
pH: 7.5
Temperature: 24.2°C
Comments: All filamentous fragments have disappeared and only microalgal cultures are present

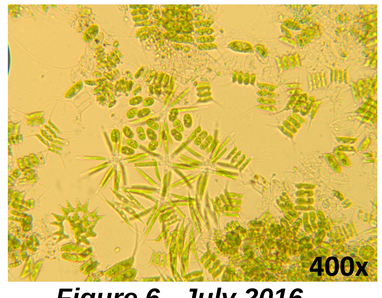


Figure 6. July 2016 (Summer)

Date: July 15, 2016
pH: 7.7
Temperature: 20.5°C
Comments: A microalgal polyculture has developed including *Scenedesmus, Actinastrum,* and *Pediastrum*

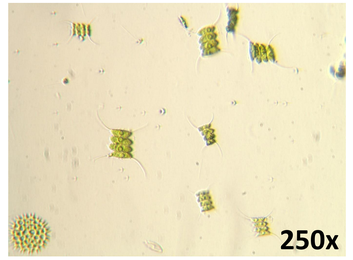


Figure 7. January 2017 (Winter)

Date: January 30, 2017
pH: 7.9
Temperature: 13.5°C
Comments: Predominantly a biculture of *Scenedesmus* and *Pediastrum*

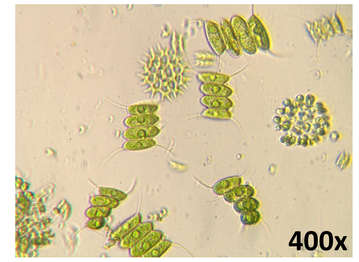


Figure 8. February 2017 (Winter)

Date: February 15, 2017
pH: 7.0
Temperature: 20.8°C
Comments: The pond has remained stable with the growing presence of *Scenedesmus* and *Pediastrum*

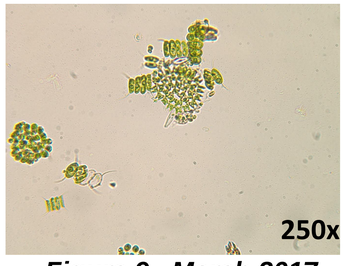


Figure 9. March 2017 (Winter)

Date: March 3, 2017
pH: 6.6
Temperature: 11.3°C
Comments: No changes

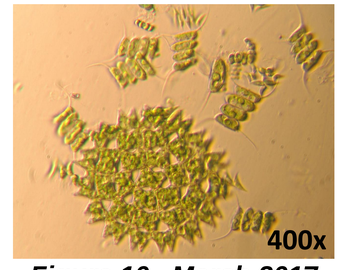


Figure 10. March 2017 (Spring)

Date: March 22, 2017
pH: 7.7
Temperature: 19.6°C
Comments: No changes

Conclusions

- Within the first seasonal change, the filamentous algae had been completely removed from the ecosystem.
- Two predominant microalgae genera, namely *Scenedesmus* and *Pediastrum*, have been able to thrive in the changing environmental site conditions over the course of all four seasons.

References

1. Ward, A., Lewis D.M., Green F.B. (2014). Anaerobic digestion of algae biomass: A review. Algal Research-Biomass Biofuels and Bioproducts, 5, 204-214.
2. APHA. (1998). *Standard Methods for the Examination of Water and Wastewater*. 20th ed. Washington DC: American Public Health Association/American Water Works Association/ Water Environment Federation.

Acknowledgements

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